Feasibility of heart rate variability analysis for welfare assessment in dolphins: a preliminary report

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Abstract

Monitoring stress and emotional states in dolphins is an important step toward improving animal welfare in managed care. Established physiological approaches, such as measuring cortisol from blood or fecal samples, have provided valuable information for stress assessment. Suction-based devices have also enabled cardiac monitoring, contributing to our understanding of diving physiology and circulatory control. Each of these methods offers unique strengths, but they may not always be suited for real-time or continuous monitoring during routine conditions.

In this study, we propose a framework in which heart rate variability (HRV) serves as a non-invasive indicator of autonomic activity, stress, and emotional states. As an initial step, we tested the feasibility of attaching a commercially available belt-type heart rate monitor to dolphins. The device was fitted safely and generally tolerated, although subtle behavioral resistance was observed in some cases. In principle, this HRV-based framework is not limited to the belt-type device tested here and could be adapted to other attachment methods, provided stable cardiac signals are obtained. Continuous cardiac signal acquisition and HRV analysis are ongoing, but these preliminary results represent a first step toward introducing HRV-based welfare assessment in cetaceans.

Future directions include refining attachment methods and implementing staged

habituation to achieve stable signal acquisition, followed by HRV analysis combined with behavioral observation. This framework has the potential to extend beyond dolphins to other marine mammals such as pinnipeds and sirenians, thereby contributing to the establishment of practical, non-invasive welfare assessment standards for zoos and aquaria.

Introduction

Assessing stress and emotional states in dolphins under human care is essential for advancing animal welfare. Traditional physiological approaches, such as measuring cortisol from blood or fecal samples, have provided valuable insight into both acute and chronic stress. Suction-based devices for cardiac monitoring have made major contributions to our understanding of diving physiology and circulatory control, and they offer relatively non-invasive access to cardiac signals. While these approaches remain highly valuable, there is still a need for complementary methods that can be applied in real time and on a continuous basis for routine welfare monitoring.

Heart rate variability (HRV) is widely recognized in human and veterinary medicine as a sensitive indicator of autonomic nervous system activity, reflecting the balance between sympathetic and parasympathetic tone. Applying HRV to dolphins offers the potential for real-time, non-invasive welfare assessment, but its feasibility under daily husbandry conditions has not yet been systematically evaluated.

Here, we report a preliminary trial testing the attachment of a belt-type heart rate monitor to dolphins. Our aim was to evaluate feasibility, animal tolerance, and potential challenges, as a first step toward developing HRV-based welfare assessment frameworks for cetaceans. Importantly, this study also introduces a new methodological approach that may allow stress and emotional states to be continuously tracked in dolphins and other marine mammals under human care, thereby contributing directly to the improvement of welfare standards in aquaria and zoos.

Methods

Animals and facility

This preliminary study was conducted with bottlenose dolphins (*Tursiops truncatus*) under human care. All animals were accustomed to cooperative training and routine health monitoring. Details of the facility are omitted for confidentiality. All procedures were carried out within the framework of positive reinforcement training and standard husbandry.

Device and preparation

A commercially available belt-type heart rate monitor was used. The belt was adjusted to fit the dolphins' body girth and secured around the thorax. The device was fully waterproof and designed for non-invasive use in aquatic conditions.

Procedure

During each trial, dolphins were cued by trainers to station voluntarily at the poolside and remained in a stable position. While the animals were stationed, the belt was gently placed and secured around the thorax. After attachment, dolphins were released to swim freely and were observed for several minutes. Behavioral responses (acceptance, resistance, avoidance) were recorded by direct visual observation, along with device retention time and stability during swimming.

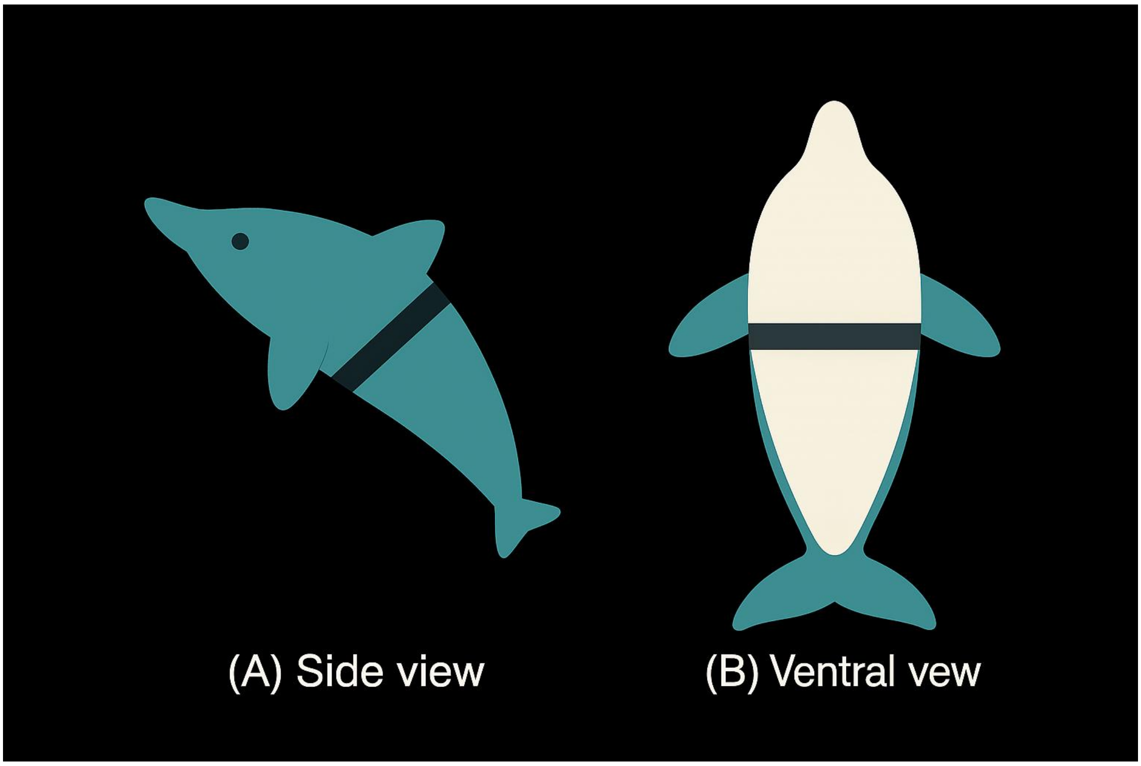
Data collection

The main evaluation criteria were **feasibility of safe attachment** and **animal tolerance**. Continuous signal acquisition was attempted but technical challenges remain; thus, HRV analyses are not yet reported here. Behavioral observations were made visually, recording signs of comfort or resistance.

Figure Legends

Figure 1. Schematic illustration of belt-type heart rate monitoring device attachment in a bottlenose dolphin.

(A) Side view: the dolphin is stationed at the poolside and a belt-type heart rate monitor is attached around the thorax, just behind the pectoral fin.



Results

- The belt-type heart rate monitor was attached safely.
- The device remained in place for several minutes during free swimming.
- No clear stress behaviors were observed.
- Mild resistance behaviors (changes in swimming patterns) were observed in some cases.

Discussion

This preliminary trial demonstrated that a belt-type heart rate monitor can be safely attached to dolphins and was generally tolerated. Minor resistance behaviors highlight the importance of staged habituation. Future efforts will focus on refining attachment methods, ensuring stable acquisition of cardiac signals, and integrating HRV analyses with behavioral observations.

Existing approaches such as cortisol measurements and suction-based devices have provided valuable insights into stress and physiology. The HRV-based framework proposed here is intended to build upon and extend these efforts by offering an additional tool that enables more continuous and practical welfare monitoring.

Furthermore, the framework demonstrated in this study may be applicable not only to dolphins but also to sea lions and seals, as well as to sirenians such as manatees. This broader application is expected to contribute to the systematization of non-invasive welfare assessments and the development of practical standards in aquaria and zoos.

Update (October 2025):

After the initial submission, heartbeats were successfully detected from a dolphin using the belt-type device. Although waveform calibration and parameter optimization are still in progress, this confirms that cardiac activity can be recorded non-invasively under routine husbandry conditions.

References

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